

MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

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No. 2.

Dr. LEE, President, in the Chair.

Henry Worms, Esq., Park Crescent, Portland Place; and
Rev. John Sargent, 6 Bentinck Terrace, Regent's Park,
were balloted for and duly elected Fellows of the Society.

Grant for a Hill Observatory in India.

The following letter was received in answer to an application for the aid of Her Majesty's Government towards the establishment for a limited period, under the superintendence of Captain Jacob, of an Observatory in the neighbourhood of Bombay, at a considerable altitude above the sea.

*Treasury Chambers,
8th August, 1861.*

In reply to your application addressed to Lord Palmerston on the 24th June last, for a grant to the Royal Astronomical Society of 1000*l.* in aid of the proposed temporary maintenance of an observatory near Poonah, I am commanded by the Lords Commissioners of Her Majesty's Treasury to acquaint you that the sum of 1000*l.* having been voted in Parliament for the object described in your letter, My Lords will be prepared to issue the

amount in such manner as you may desire, on the understanding that the Society will see to the proper application of the fund thus placed at its disposal.

I have the honour to be, Gentlemen,

Your obedient servant,

(Signed) GEO. A. HAMILTON.

*The President and Treasurer of the Royal Astronomical Society,
Somerset House.*

A letter was sent to his Lordship expressing the thanks of the Council for the promptness with which their application had been met.

The foregoing grant was announced by the President at the November Meeting, and should have been mentioned in the last number of the *Notices*.

On the Right Ascensions and Declinations of the Radcliffe Catalogue. By Dr. Wolfers.

(Communicated by the Rev. R. Main.)

The Radcliffe Trustees having presented to me the observations made at the Radcliffe Observatory, Oxford, vols. xviii. and xix., I have compared the places of stars contained in these two volumes with those contained in the *Tabulæ Reductionum*. Having combined these two series of differences with the earlier-obtained series (*Astr. Nachr.*, No. 1181), I have obtained the table of comparisons which I now send.

Excluding only the R.A. of the two polar stars α and δ *Ursæ Minoris*, the result of the comparison is

J. — W.			
Number of Observations.	R.A.	Number of Observations.	Decl.
347	+ 0 ^s .026	288	+ 0 ^{''} .046

Excluding, moreover, the R.A. of the circumpolar stars α *Ursæ Majoris*, γ *Ursæ Majoris*, and β *Ursæ Minoris*; further excluding the R.A. of α *Geminorum*, because in the *Tab. Red.* there is given the mean of the R.A. of α^1 and α^2 *Geminorum*, but in the observations the R.A. of each of them, the difference of the two R.A. given in the *Astr. Jahrbuch* being not very accurate, the result of the whole comparison is

J. — W.			
Number of Observations.	R.A.	Number of Observations.	Decl.
326	+ 0 ^s .017	288	+ 0 ^{''} .046

To the R.A. of α *Canis Majoris* the correction of M. Peters is applied; and these differences being reduced to the year 1860,

J. denotes the co-ordinates observed at Oxford, W. denotes the co-ordinates given in the *Tab. Red.*

The Right Ascensions and Declinations of Fundamental Stars observed at the Radcliffe Observatory, compared with those contained in the Tabulæ Reductionum.

Name of Star.	Number of Observations.	J. — W. R. A.	Number of Observations.	[J. — W. Decl.
α Andromedæ ...	4	+0°02	5	+0°7
γ Pegasi ...	9	—0°04	6	+2°6
α Cassiopeiæ ...	3	+0°09	4	—0°4
α Arietis ...	6	—0°02	3	+1°5
α Ceti ...	9	+0°01	4	+0°4
α Persei ...	5	—0°06	3	—0°2
α Tauri ...	16	—0°02	9	+0°2
α Aurigæ ...	5	—0°01	6	—0°6
β Orionis ...	8	0°00	7	+0°4
β Tauri ...	5	+0°05	6	+2°5
α Orionis ...	8	+0°02	5	+1°4
α Canis Majoris...	8	—0°02	20	—0°4
α Geminorum ...	10	+0°12	8	+1°8
α Canis Minoris...	11	+0°03	9	+0°6
β Geminorum ...	16	—0°01	10	+0°3
α Hydræ... ..	9	+0°06	7	—2°1
α Leonis... ..	15	+0°01	12	+1°1
α Ursæ Majoris ...	5	+0°32	12	+0°6
β Leonis ...	9	+0°08	6	—0°3
β Virginis ...	9	+0°13	5	—0°4
γ Ursæ Majoris...	5	+0°21	2	+0°2
α Virginis ...	12	+0°08	14	—1°3
η Ursæ Majoris ...	10	+0°06	2	—0°8
α Bœotis ...	6	+0°02	2	+0°4
α^1 Libræ... ..	1	+0°04	4	—0°4
α^2 Libræ ...	10	+0°10	3	—0°6
β Ursæ Minoris...	1	—0°26	5	—0°1
α Coronæ ...	9	+0°01	3	—0°7
α Serpentis ...	10	0°00	3	—0°4
α Scorpii... ..	12	+0°14	7	—0°2
α Herculis ...	6	—0°10	1	—0°2
α Ophiuchi ...	10	—0°02	8	—0°1
γ Draconis ...	5	+0°03	4	—0°8
α Lyræ ...	11	+0°07	8	—0°4
γ Aquilæ... ..	6	0°00	3	—0°7

Name of Star.	Number of Observations.	J. — W. R. A.	Number of Observations.	J. — W. Decl.
α Aquilæ ...	10	^s — 0° 05	9	+ 0° 3
β Aquilæ ...	4	+ 0° 02	4	— 0° 2
α^1 Capricorni ...	—	—	2	— 1° 8
α^2 Capricorni ...	5	+ 0° 01	5	— 2° 8
α Cygni ...	8	— 0° 01	6	— 2° 4
α Cephei... ..	11	— 0° 07	7	+ 0° 9
β Cephei... ..	4	— 0° 11	10	+ 0° 2
α Aquarii ...	9	— 0° 06	2	— 1° 0
α Piscis Australis	8	— 0° 02	8	— 0° 4
α Pegasi	4	— 0° 12	6	— 0° 3
α Ursæ Minoris...	8	— 0° 24	4	0° 0
δ Ursæ Minoris...	4	+ 0° 48	9	+ 1° 8

Berlin, November 30, 1861.

On the Secular Acceleration of the Moon's Mean Motion.

By A. Cayley, Esq. (Abstract.)

The inclination and excentricity of the Moon's orbit, and *à fortiori* the variation of the position of the ecliptic, and the latitude of the Sun, are neglected; and the longitudes are measured from a fixed point in the ecliptic. The notation is in the present Abstract explained in so far only as it presents any peculiarity. I take

n , the actual mean motion of the Moon at a given epoch;

viz., it is assumed that the mean longitude at the time t is $\epsilon + nt + n_2 t^2 + \&c.$ where $\epsilon, n, n_2, \&c.$ are absolute constants; and, moreover,

a , the calculated mean distance of the Moon;

that is, $n^2 a^3$ is the sum of the masses of the Earth and Moon; a is, therefore, an absolute constant.

$$m, = \frac{n'}{n}, \text{ is an absolute constant.}$$

The Sun is considered as moving according to the law of elliptic motion in an orbit the excentricity whereof is $e' + \delta e'$, or $e' + f' t$, where e', f' , are absolute constants.

In the expression of the disturbing function the Sun's mass is taken to be $= n'^2 a'^3$, or, what is the same thing, $= m^2 n^2 a'^3$.

Then r , v , being the radius vector and longitude of the Moon, and taking the usual approximate expression of the disturbing function, the equations of motion are

$$\frac{d}{dt} \frac{dr}{dt} - r \left(\frac{dv}{dt} \right)^2 + \frac{n^2 a^3}{r^2} = m^2 n^2 a'^3 \frac{r}{r'^3} \left(\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' \right),$$

$$\frac{d}{dt} \frac{r^2 dv}{dt} = m^2 n^2 a'^3 \frac{r^2}{r'^3} \left(-\frac{3}{2} \sin 2v - 2v' \right);$$

or writing

$$\frac{r}{a} = \varrho, \quad \frac{r'}{a'} = \varrho',$$

we have

$$\frac{d}{dt} \frac{\partial \varrho}{\partial t} - \varrho \left(\frac{dv}{dt} \right)^2 + \frac{n^2}{\varrho^3} = m^2 n^2 P,$$

$$\frac{d}{dt} \left(\varrho^2 \frac{dv}{dt} \right) = m^2 n^2 Q,$$

where, for shortness,

$$P = \frac{\varrho}{\varrho'^3} \left(\frac{1}{2} + \frac{3}{2} \cos 2v - 2v' \right),$$

$$Q = \frac{\varrho^2}{\varrho'^3} \left(-\frac{3}{2} \sin 2v - 2v' \right).$$

The notation is then changed by writing $\varrho' + \delta \varrho'$, $v' + \delta v'$, in the place of ϱ' , v' ; using henceforward ϱ' , v' , to denote the elliptic values of the solar co-ordinates, as calculated with the constant excentricity ϱ' ; and, moreover, $\varrho + \delta \varrho$, $v + \delta v$, in the place of ϱ , v ; using henceforward ϱ , v , to denote the values of the lunar co-ordinates obtained from the equations of motion by writing therein ϱ' , v' , instead of the complete values $\varrho' + \delta \varrho'$, $v' + \delta v'$. Then putting

$$\delta P = \frac{dP}{\partial \varrho} \delta \varrho + \frac{dP}{\partial v} \delta v + \frac{dP}{\partial \varrho'} \delta \varrho' + \frac{dP}{\partial v'} \delta v',$$

with a like value for δQ , and observing that the equations of motion are satisfied when $\delta \varrho$, δv , $\delta \varrho'$, $\delta v'$, are neglected, we have

$$\frac{d}{dt} \frac{\partial \delta \varrho}{\partial t} - \delta \varrho \left(\frac{dv}{dt} \right)^2 - 2 \varrho \frac{dv}{dt} \frac{\partial \delta v}{\partial t} - \frac{2 n^2}{\varrho^3} \delta \varrho = m^2 n^2 \delta P,$$

$$\frac{d}{dt} \left(\varrho^2 \frac{\partial \delta v}{\partial t} + 2 \varrho \delta \varrho \frac{dv}{dt} \right) = m^2 n^2 \delta Q;$$

or, integrating the second equation, and by means of such integral changing the form of the first equation, we have

$$\frac{d^2 \delta \varrho}{dt^2} + n^2 \delta \varrho = \left\{ n^2 + \frac{2n^2}{\varrho^3} - 3 \left(\frac{d\psi}{dt} \right)^2 \right\} \delta \varrho + m^2 n^2 \left\{ \delta P + \frac{2}{\varrho} \frac{dv}{dt} \left(C + \int \delta Q dt \right) \right\},$$

$$\frac{d\delta v}{dt} = -\frac{2}{\varrho} \frac{dv}{dt} \delta \varrho + \frac{m^2 n^2}{\varrho^2} \left(C + \int \delta Q dt \right),$$

where C is to be determined by the condition that $\frac{d\delta v}{dt}$ may contain no constant term (for otherwise nt would not be the whole term varying directly as the time, in the longitude $v + \delta v$). The values of ϱ' , v' , $\delta \varrho'$, $\delta v'$, are given by the theory of elliptic motion, and those of ϱ , v , by the ordinary lunar theory, in which the excentricity of the solar orbit is treated as a constant; the integration of the last-mentioned equations leads to the values of $\delta \varrho$, δv , and then the radius vector and longitude of the moon are $\varrho (\varrho + \delta \varrho)$, $v + \delta v$, respectively.

We, in fact, have

$$\begin{aligned} \frac{1}{\varrho} &= 1 + \frac{1}{6} m^2 \\ &+ \frac{3}{2} m^2 e' \cos g' \\ &+ m^2 \quad , \quad 2\tau \\ &+ \frac{7}{2} m^2 e' \quad , \quad 2\tau - g' \\ &- \frac{1}{2} m^2 e' \quad , \quad 2\tau + g' \end{aligned}$$

$$v = nt + \varepsilon$$

$$\begin{aligned} &- 3 m e' \sin g' \\ &+ \frac{11}{8} m^2 \quad , \quad 2\tau \\ &+ \frac{77}{16} m^2 e' \quad , \quad 2\tau - g' \\ &- \frac{11}{8} m^2 e' \quad , \quad 2\tau + g' \end{aligned}$$

$$(g' = c' m nt + \text{const.} \quad 2\tau = (2 - 2m) nt + \text{const.})$$

$$\begin{aligned}
\frac{1}{\varrho} &= 1 \\
&+ e' \cos g' \\
v' &= n' t + \varepsilon \\
&+ 2 e' \sin g' \\
\delta \frac{1}{\varrho} &= 1 \quad t \cos g' \\
&+ 2 e' \quad ,, \quad 2 g' \\
\delta v' &= 2 \quad t \sin g' \\
&+ \frac{5}{2} e' \quad ,, \quad 2 g'
\end{aligned}$$

where, instead of $\delta e' = f' t$, $\delta e'$ has been put $= t$, a simplification which is employed throughout the working, the factor f' being restored in the final results.

The values in the first instance obtained for $\delta \varrho$, δv , are

$\delta \varrho = f'$ into as follows, viz.:

$$\begin{aligned}
&\frac{3}{2} m^2 e' t && + \overbrace{n^{-1} \times} \\
&+ \frac{3}{2} m^2 \quad t \cos g' && 3 m^3 \quad \sin g' \\
&+ 5 m^2 e' \quad ,, \quad 2 \tau, && - \frac{203}{12} m^2 e' \quad ,, \quad 2 \tau \\
&- \frac{7}{2} m^2 \quad ,, \quad 2 \tau - g' && + \frac{61}{24} m^2 \quad ,, \quad 2 \tau - g' \\
&+ \frac{1}{2} m^2 \quad ,, \quad 2 \tau + g' && - \frac{91}{14} m^2 \quad ,, \quad 2 \tau + g' \\
&+ \frac{9}{2} m^2 e' \quad ,, \quad 2 g' && - 18 m^3 e' \quad ,, \quad 2 g' \\
&- 17 m^2 e' \quad ,, \quad 2 \tau - 2 g' && + \frac{85}{6} m^2 e' \quad ,, \quad 2 \tau - 2 g' \\
&0 \quad ,, \quad 2 \tau + 2 g' && - \frac{3}{4} m^2 e' \quad ,, \quad 2 \tau + 2 g'
\end{aligned}$$

and

$\delta v = f'$ into as follows, viz.:

$$\begin{aligned}
&- \frac{3}{2} m^2 n e' t^2 \\
&- 3 \quad t \sin g' && + \overbrace{n^{-1} \times} \\
&&& - 3 + 6 m^2 \cos g'
\end{aligned}$$

$$\begin{array}{ll}
- \frac{55}{8} m^2 e' \sin 2\tau & - \frac{74}{3} m^2 e' \cos 2\tau \\
+ \frac{77}{16} m^2 & ,, 2\tau - g' \quad + \frac{215}{48} m^2 & ,, 2\tau - g' \\
- \frac{11}{16} m^2 & ,, 2\tau + g' \quad - \frac{257}{48} m^2 & ,, 2\tau + g' \\
- \frac{9}{2} m e' & ,, 2g' \quad \left(-\frac{9}{4} + 18m^2\right) e' & ,, 2g' \\
+ \frac{187}{8} m^2 e' & ,, 2\tau - 2g' \quad + \frac{2239}{96} m^2 e' & ,, 2\tau - 2g' \\
0 & ,, 2\tau + 2g' \quad - \frac{33}{32} m^2 e' & ,, 2\tau + 2g'
\end{array}$$

where it is to be noticed that the terms $t \cos \arg.$ and $t \sin \arg.$ arise from the substitution of $e' + f' t$ for e' in the coefficients of the terms $\cos \arg.$ and $\sin \arg.$ in the ordinary values of ϱ and v . The new periodic terms $\sin \arg.$ in $\delta \varrho$ and $\cos \arg.$ in δv agree as to the arguments $g', 2\tau, 2\tau - g', 2\tau + g'$, with those obtained by Prof. Adams; those for the other arguments $2g', 2\tau - 2g', 2\tau + 2g'$, do not contribute to the formation of the term in m^4 of the acceleration.

Starting from the foregoing expressions of $\delta \varrho$ and δv , and proceeding to calculate the non-periodic parts as far as m^4 , the results are found to be

$$\delta \varrho = \left(\frac{3}{2} m^2 - \frac{1973}{32} m^4 \right) e' f' t,$$

where the number $\frac{1973}{32}$ is made up

$$- \frac{1973}{32} = \frac{381}{8} - \frac{495}{32} - \frac{15}{4} - \frac{647}{32} - \frac{1455}{16} + \frac{675}{32};$$

and

$$\delta v = \left(-\frac{3}{2} m^2 + \frac{3771}{64} m^4 \right) n e' f' t^2,$$

where the number $\frac{3771}{64}$ is obtained by means of the before-mentioned number $\frac{1993}{32}$; but replacing this number $\frac{1973}{32}$ by its component terms, the number $\frac{3771}{64}$ is made up

$$\frac{3771}{64} = -\frac{381}{8} + \frac{495}{32} + \frac{15}{4} + \frac{647}{32} + \frac{1455}{16} - \frac{675}{32} + \frac{275}{16} + \frac{45}{16} - \frac{1455}{64}.$$

It is hardly necessary to remark that, f'^2 being neglected, $2 e' f' t = (e' + f' t)^2 - e'^2$, and $\therefore e' f' t^2 = \int [(e' + f' t)^2 - e'^2] dt$, where $(e' + f' t)^2 - e'^2$ is what is commonly represented by $(e'^2 - E'^2)$. The value of m is not that made use of by Prof. Adams; in fact,—

$$m \text{ (Adams)} = m \left\{ 1 + \left(\frac{3}{2} m^2 - \frac{3771}{64} m^4 \right) 2 e' f' t \right\}$$

but in the terms multiplied by f' the two values of m may be considered as identical, hence the foregoing expression of δv , in the notation of Prof. Adams, is

$$\delta v = \left(-\frac{3}{2} m^2 + \frac{3771}{64} m^4 \right) \int (e'^2 - E'^2) n dt$$

the result obtained by him. The number $\frac{1973}{32}$, the coefficient of m^4 in the expression δe , does not occur explicitly in his memoir, but is, in fact, deducible from the value there given for the reciprocal of the radius vector. The present abstract gives a complete outline of the method of investigation, and it was thought better to omit altogether the details of the working rather than present them in an incomplete manner.

The Transit of Mercury, Nov. 11, 1861.

(Extract of a Letter from Father Secchi to the Astronomer Royal, dated Rome, Nov. 16, 1861.)

The passage of *Mercury* on the solar disk has been observed here under very good circumstances, but almost by a miracle, because the sky was all overcast by clouds. Some details will be found in the *Comptes Rendus*, and more yet in the *Astronomische Nachrichten*. But it will not displease the Astronomical Society to know the principal results; they are the following:—

	^h	^m	^s
Interior contact, Sid. T. Rome ...	13	35	6.29
Or M.T. Rome	22	9	9.45
Centre (estimated), Sid. T.	13	36	10.19
Exterior contact, Sid. T.	13	37	14.09

The air was exceedingly calm, and the rupture of the narrow ring was made with the utmost tranquillity, leaving two very sharp cusps. The exterior edge of the Sun appeared in the narrow thread of light, before the rupture, more faint

a good deal than the part of the Sun at the opposite point of the diameter of the planet. The blackness of the planet appeared greater a good deal than the usual nuclei of the spots, and its termination persuaded me that the nuclei are really badly terminated, and that there is a real diffusion of matter in their borders. In the intervals left between the clouds, during the passage, I measured a great many distances and positions of the planet from the edge of the Sun's disk; and I made, also, 9 double measures of the diameter of the planet. The result of these is $=9''.077$, with probable error $=0''.189$. It is remarkable that the duration of the passage gives for this diameter $9''.165$. This value is different from that given in the tables. A year ago I obtained from some measures a diameter even smaller—that is, $8''.91$. I propose to take a few more measures of this element; but it is rather difficult, on account of the termination of *Mercury's* disk, which is always very bad, and seems to be very faint at the edges.

A new discussion of my magnetical observations compared with a series of electrical atmospherical observations have led me to admit a real connexion between this electricity, and the variations of at least the horizontal intensity. In many things, I think, M. Lamont is right; and what he has suggested on this account I believe him to have demonstrated and seen directly.

The Transit of Mercury, November 11, 1861, observed at Malta. By W. Lassell, Esq.

At No. 9, Piazzì Stiernà, Via Torre, Malta, approximate longitude $58^m 2^s$ east of Greenwich, latitude $35^\circ 54' 46''$ north, 1861, Nov. 11th, I observed the emersion, or egress, and part of the transit of *Mercury* over the Sun. The best telescope I had at hand was a very sharply-defining Gregorian of 4.7 inches aperture; power used, 78. I first pointed the telescope at about 19.50 Stiernà mean time. The planet, being considerably advanced on the disk, appeared perfectly well defined, round, and black. I watched the phenomenon from time to time until about 22^h; after which I observed it uninterruptedly until its disappearance. I had, however, no means suitable for making any accurate measures; but I was filled with admiration, throughout, of the exquisite beauty of the vision. The limb of the Sun and the disk of the planet were far more sharp and beautiful than I have ever seen them with equal power, and within $1\frac{1}{2}$ to 3 hours of the horizon.

Notwithstanding that the heat of the Sun was so great as to make a shield necessary for the exposed part of my person (though I was generally well protected by a verandah), yet the image was, with occasional slight disturbances, as sharp as can be conceived, and afforded a striking contrast to all I have seen before.

I scrutinised the planet well throughout its transit, but could not be sure of any peculiarity. I repeatedly *fancied* it a little elliptical, but I do not believe in the reality of the appearance.

The times are given in Stierna mean time; they were noted with a duplex watch, compared with a standard mean time clock, accurately corrected and rated by sextant observations.

At $22^h 15^m 57^s.1$ the planet was estimated to be just its own diameter from the Sun's limb.

At $22^h 16^m 13^s.5$ it was clearly within one diameter.

At $22^h 18^m 5^s.9$, first contact. Shortly after, the planet seemed momentarily drawn out towards the limb, pear-like.

At $22^h 18^m 53^s.5$ the Sun's limb bisected the planet. No distortion whatever. Shortly afterwards I had a momentary impression of the lengthening out of the diameter which was a tangent to the Sun's limb, or which had just passed it.

At $22^h 20^m 21^s.5$, last contact, *i. e.* the first moment that I was sure that the planet was no more to be seen.

It has rarely been my lot to observe an astronomical phenomenon with circumstances so favourable and pleasant.

I have much pleasure in stating that I have erected the 4-foot equatoreal telescope on a very excellent site, across the Quarantine Harbour from Valetta, and nearly north of it, within a short distance of Fort Tigné.

A boundary wall, inclosing an area twenty yards square, in the centre of which the telescope stands, and a sufficiently capacious laboratory adjacent, are on the point of completion. The observing tower is in process of erection, and I hope very shortly to commence operations.

Observations of the Transit of Mercury, November 11, 1861, made at the Observatory, Durham. By Prof. T. Chevallier.

The weather was very favourable, at Durham, for observing the transit of *Mercury* on the 11th of November. At sunrise the eastern part of the sky was almost cloudless, and continued so till the emersion of the planet. The Sun's limb, however, in consequence of his low altitude and the state of the atmosphere, was very undulating.

Mercury was seen upon the Sun's disk immediately after sunrise, his appearance as a round black spot contrasting strongly with that of some ordinary spots on the Sun's surface.

The instruments used, in different rooms, were the Northumberland Equatoreal, of 7 feet 4 inches focal length and 5 inches aperture, and the Fraunhofer Equatoreal, of 8 feet 3 inches focal length and 6.5 inches aperture.

The internal and external contacts were observed as follows, in Durham sidereal time :—

	Northumberland Telescope. Prof. Chevallier.	Fraunhofer's Telescope. Mr. A. Marth.
	h m s	h m s
Internal contact ...	12 38 52.68	12 38 54.0
External contact ...	12 40 53.61	12 40 59.0

Each of these observations was difficult, in consequence of the undulations of the Sun's limb. An instant before the internal contact, the thin curved line of light between the planet and the Sun's limb seemed to break up, by the sudden filling up of the two cusps by a black space. This appearance was, no doubt, occasioned by the tremulous motion affecting the Sun's limb. The exact time of the external contact was rendered uncertain from the same cause.

The times, computed from Le Verrier's Tables by the formulæ given by Dr. Schjellerupp (*Astronomische Nachrichten*, No. 1286), are,

	Durham Sid. Time.
	h m s
Internal contact ...	12 38 55.12
External contact ...	12 41 10.60

Mr. Marth made the following observations of the difference of R.A. and declination of the Sun and planet, with a wire micrometer, each observation in R.A. being made on five wires, and five different measures having been taken of the difference of declination of *Mercury* and the Sun's northern limb:

Durham Sid. Time, Nov. 11.	Greenwich M.T.	Diff. of R.A. $\gamma - \odot$ corrected for Refraction and Proper Motion.	No. of Obs.	Corrected for Parallax.	Computed from Schjellerupp.	C—O.
h m s	h m s	s		s	s	s
11 58 22.9	20 38 49.5	-11.192	2	-11.308	-11.558	-0.25
12 5 8.0	45 33.4	-13.770	2	-13.883	-14.111	-0.23
28.16.7	21 8 38.4	-22.871	2	-22.971	-22.886	+ .08

		Diff. of Decl. $\gamma - \odot$ N. Limb.	No. of Mea- sures.	Corrected for Parallax.	
12 ^h 21 ^m 5 ^s .4	21 ^h 1 ^m 28 ^s .2	-2' 6".96	5	-2' 3".45	-1' 59".07 + 4".38

*Observations of the Transit of Mercury, November 11, 1861,
at and near Liverpool.*

(Communicated by Mr. Hartnup.)

Observed by Mr. Hartnup, at the Liverpool Observatory, with the Equatoreal Refractor, aperture reduced to 4 inches, power 288, parallel wire micrometer.

By mean of 6 measures, equatoreal diameter = $10^{\circ}09''$

By mean of 6 measures, polar diameter = $9^{\circ}72''$

The tremor was great, but the observations were taken with great care.

Egress.

		^h	^m	^s	
Interior contact.....	21	19	14	40	G.M.T.
Exterior contact ...	21	21	25	74	

The time was taken from the sidereal clock, which was $3^{\text{s}}.33$ fast. The fine line of light appeared broken at $12^{\text{h}} 33^{\text{m}} 9^{\text{s}}$, but it instantly united again, and between 9^{s} and 20^{s} it broke and united several times; after 20^{s} the separation remained permanent. I have taken $14^{\text{s}}.5$ as the most probable time of interior contact. Contrary to expectation, the last contact was observed with less difficulty than the first; the separation of the planet from the Sun's limb was instantaneous, and may, I think, be depended on to one second of time.

Egress observed by John Joynson, Esq., at Waterloo, near Liverpool:—

		^h	^m	^s	
Interior contact ...	21	19	14	5	G.M.T.
Exterior contact...	21	21	9	5	

Latitude $53^{\circ} 28' 24''$ N. Longitude $3^{\circ} 1' 44''$ W.

Observed with a refractor of $3\frac{1}{2}$ inches aperture and 50 inches focal length. The time was taken from a chronometer, the error of which was obtained from the Liverpool Observatory.

Egress observed by Matthew Jee, Esq., at Edge Hill, Liverpool:—

		^h	^m	^s	
Interior contact ...	21	20	0		G.M.T.
Exterior contact...	21	21	20		

Latitude $53^{\circ} 24' 27''$ N. Longitude $11^{\circ} 49' 4''$ W.

Observed with a Dollond's refractor, $2\frac{1}{8}$ inches aperture ; power 80. The time was taken from the seconds clock in the office-window of the Magnetic Telegraph Company. This clock is controlled from the Liverpool Observatory.

The Transit of Mercury, November 11, 1861, observed at Grantham. By J. W. Jeans, Esq.

Lat. $52^{\circ} 54' 52''$ N.

Long. $0^{\circ} 39' 0''$ W.

Morning fine, but rather hazy ; a good many light clouds ; wind moderate, and atmosphere very tremulous ; vision at times good. The first observation I consider very fair, the last rather uncertain ; telescope 5 feet focal length, achromatic, of 4 inches aperture, reduced to 2 inches ; power 80. I was rather impressed with the idea that the figure of *Mercury* was not quite round, but slightly elongated, and that there was also a slight ashy light on his eastern limb. At best visions the outline of the planet was sharp, and the impression of ellipticity doubtful ; no appearance of atmosphere ; clock corrected by transit of δ *Leonis* the same morning, and by Fomalhaut and Markab the previous evening.

First break (pretty good)...	^h 12 ^m 42 ^s 38'03	} Apparent Local Sid. Time.
Last contact (middling) ...	12 44 44'03	

Grantham, December 5, 1851.

Observations of the Transit of Mercury, November 11, 1861. By Joseph Baxendell, Esq.

The following observations were made at Mr. Worthington's Observatory, the instrument used being the equatorially-mounted achromatic of 5 inches aperture and 70 inches focal length. A power of 126 was first applied ; but, owing to the unsteadiness of the atmosphere at so low an altitude, micro-metrical measurements of the diameter of *Mercury* were found to be quite impracticable. Two measures of the planet's position on the Sun's disk were taken under a power of 68, but a light cirrous cloud was passing slowly over the Sun at the time, and the images were still very tremulous. The mean result, corrected for refraction and parallax, was as follows :—

^{h m s}
At 21 4 10'2 G.M.T. App. R.A. of *Mercury* = App. R.A. of Sun — 20^s 74
App. N.P.D. of *Mercury* = App. N.P.D. of Sun — 14' 14'' 5

A few minutes before the end of the transit the cloud passed away, and the definition of the planet and of the Sun's limb improved considerably, and the internal and external contacts were observed very satisfactorily.

The internal contact took place at	$21^{\text{h}} 19^{\text{m}} 8^{\text{s}}.68$	G.M.T.
The external	ditto	$21^{\text{h}} 21^{\text{m}} 22^{\text{s}}.80$ „

When the planet was about one-fourth or one-third of its own diameter from the Sun's limb, its form was observed to change slightly; and at the moment of internal contact it was decidedly egg-shaped, the small end of the egg being next to the Sun's limb. The only other feature observed worthy of notice was the excessive *blackness* of the planet, as compared with the nuclei of the spots then visible on the solar disk.

In connexion with the apparent alteration of form of the planet, I may perhaps be allowed to give an extract from my journal, describing a similar appearance observed by my friend Mr. S. W. Williamson, of Cheetham Hill, and myself, on the occasion of the transit of *Mercury* which occurred Nov. 9th, 1848. The telescope employed was an excellent equatorially-mounted achromatic, of $3\frac{1}{4}$ inches aperture and 42 inches focal length, belonging to Mr. Williamson, and the image of the Sun was thrown on a screen. This image was very well defined, and exhibited the usual features of the solar surface with great distinctness:—

“At the ingress of the planet a remarkable distortion of its image took place. When the planet had advanced nearly its own diameter on the Sun's disk, the image, instead of immediately assuming a full circular figure, gradually lengthened out on the following side into a pear-like form, until the planet had advanced about one-and-a-half of its own diameter on the Sun's disk, when the projecting part disappeared instantaneously, and the Sun's light closed round the planet, exhibiting it removed a very sensible distance from the limb of the Sun.”

As the apparent diameter of *Mercury*, when on the sun's disk, is probably diminished by the effect of irradiation, the alteration of its form, on approaching or leaving the limb, as noticed by some observers, may perhaps be due to the diminished effect of irradiation consequent upon the rapidly diminishing intensity of the Sun's light near the limb, and to the greater susceptibility of some eyes than others to the effects of irradiation; and I may remark that, to my own eye, the degradation of the light of the Sun's disk near the border, whether seen directly through the telescope or projected on a screen, is always very strikingly evident.

Manchester, Dec. 12, 1861.

On the Elements of the Variable Star R Sagittæ.

By Joseph Baxendell, Esq.

This star was discovered to be variable in October, 1859; and in a notice of it which I communicated to the Physical Section of the Manchester Literary and Philosophical Society, on the 5th January, 1860, its period was stated to be about 74 days, and its range of variation to be from the 9·8 magnitude at minimum to the 8·4 magnitude at maximum. The observations which I have since made have, however, enabled me to determine its elements with much greater accuracy than could be expected in a first approximation, and have also shown that it merits attention as being one of the very few but interesting variables, the light-curves whereof exhibit a distinctly marked *secondary* minimum. Many of the variables occasionally exhibit decided deviations from the ordinary course of their changes; but the cases are very rare in which a secondary minimum forms a permanent feature in the curves laid down from observations extending over several successive periods.

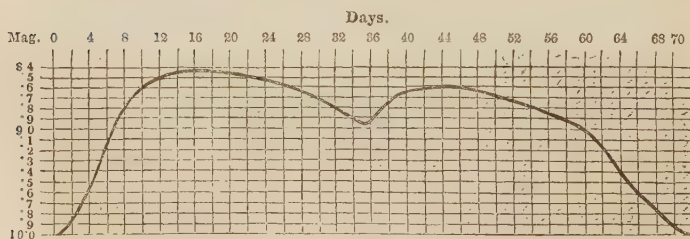
During the two years which have elapsed since I first noticed the variability of R *Sagittæ*, I have obtained the following determinations of the times of nine of its principal minima:—

1. 1859, Oct. 27	6. 1860, Dec. 27
2. 1860, Jan. 7	7. 1861, May 17
3. „ May 31	8. „ July 25
4. „ Aug. 7	9. „ Oct. 8
5. „ Oct. 19	

Treating the equations formed from these data by the method of least squares, I find that the

Epoch = 1860, Oct. 17·13

Period = 70·88 days



Light-curve of R *Sagittæ*. Period = 70·88 days.

Calculating the times of the minima by means of these elements, and comparing the calculated with the observed results, we have

C — O.	C — O.
days.	days.
1. + 1 ^h 73	6. + 0 ^h 01
2. + 0 ^h 61	7. + 0 ^h 77
3. — 2 ^h 63	8. + 2 ^h 65
4. + 0 ^h 25	9. — 1 ^h 47
5. — 1 ^h 87	

These differences show that the variations in the length of the period of R *Sagittæ* are confined within moderate limits, and that this star may be ranked in the class of moderately regular variables.

Using the mean period of 70^h 88 days in combining all the observations made in the different phases of the star's changes, and projecting the mean results in the usual way, I find, from the curve thus obtained, that the principal maximum, the secondary minimum, and the secondary maximum, follow the principal minimum in 17, 35, and 44 days respectively. It appears, therefore, that the interval between the principal and the secondary minimum is almost exactly one-half of the whole period, precisely as in the case of the well-known double-period variable, β *Lyræ*.

The mean magnitude at the principal minimum = 10^o 00

„ maximum = 8^h 45

secondary minimum = 8^h 95

„ maximum = 8^h 60

The lowest minimum yet observed is 10^h 3, and the highest maximum 8^h 3; the greatest range of variation is, therefore, 2^h 0 magnitudes.

The mean place of the star for 1860^o 0 is

R.A. 20^h 7^m 40^s;

Decl. 16° 18' 3 N.

Manchester, Dec. 9, 1861.

On the Variable Star R Vulpeculæ. By G. Knott, Esq.

R *Vulpeculæ*. Piazzi xx. 457. My earliest observations of this variable were made on the 7th, 9th, and 10th of September, when it shone as a star of the 9^h 3 magnitude. Bad weather and absence from home prevented another observation till the 26th of the month, when, to my surprise, I found it considerably fainter, and of the 11^h 7 magnitude. Since that date I have

kept the star pretty constantly in view; and the discussion and projection of my observations give October 27th as the epoch of *minimum*, just two days prior to the date of probable *maximum*, as given in Mr. Pogson's ephemeris. The magnitude at minimum appears to have been about 13.6.

As this is the first communication I have had the honour of submitting to the Astronomical Society, it will probably be deemed desirable that I should briefly describe my instrument and method of observing variable stars.

My Observatory is furnished with a 9-foot equatoreal, the object-glass by Messrs. Alvan Clark and Sons, and of $7\frac{1}{2}$ inches aperture. It was formerly in the possession of the Rev. W. R. Dawes, and was very favourably spoken of by him—a sufficient guarantee of its quality. I usually employ an excellent positive eyepiece, constructed for me by Mr. Dollond; it has a large field, and gives a magnifying power of 60, as determined by measuring the emergent pencil. Higher magnifiers are occasionally employed.

In observing and discussing observations of variable stars, I have adopted Mr. Pogson's methods, as also his magnitude-scale (Argelander's extended). I am largely indebted to him, not only for his interesting and important papers in the *Astronomische Nachrichten* and the *Monthly Notices*, but also for several valuable hints in one or two personal communications with which he has favoured me. In all probability I am not the only amateur who is eagerly expecting his promised *Variable Star Atlas*.

Observations of Comet II. 1861, taken with the Equatoreal of the Liverpool Observatory. By J. Hartnup, Esq.

	G.M.T.			Comet's R.A.			Log. $\frac{p}{P}$	Comet's N.P.D.			Log. $\frac{q}{P}$	Stars of Comp. B.A.C.
1861.	h	m	s	h	m	s		°	'	"		
July 3	10	44	32.7	9	42	13.06	+8.950	24	5	59.1	-9.7407	3496
3	11	21	16.0	9	44	3.75	+8.910	24	2	49.5	-9.7955	"
4	10	54	4.6	10	50	43.43	+8.999	23	5	31.0	-9.6858	3647
4	11	25	20.0	10	52	4.32	+8.985	23	5	33.0	-9.7790	"
4	11	56	34.8	10	53	25.01	+8.962	23	5	38.1	-9.8644	"
5	11	3	34.1	11	46	10.28	+8.996	23	40	24.6	-9.5207	3968
5	11	29	11.1	11	46	50.71	+8.993	23	41	20.6	-9.5831	"
5	11	49	48.5	11	47	31.40	+8.987	23	42	20.9	-9.6337	"
6	10	3	56.4	12	25	23.85	+8.938	24	54	1.5	-9.0806	4276
6	10	24	23.6	12	25	53.65	+8.953	24	55	15.0	-9.2173	"
6	10	44	50.5	12	26	23.61	+8.963	24	56	30.5	-9.3213	"
7	10	24	25.2	12	55	52.79	+8.909	26	26	4.5	-9.1219	4300
7	10	54	53.7	12	56	24.84	+8.931	26	28	3.7	-9.2909	4276

	G.M.T.			Comet's R.A.			Log. $\frac{p}{P}$	Comet's N.P.D.			Log. $\frac{q}{P}$	Stars of Comp. B.A.C.
1861.	h	m	s	h	m	s		°	'	"		
July 7	11	25	21.4	12	56	57.20	+8.944	26	30	6.0	-9.4211	4276
8	10	58	56.3	13	18	27.06	+8.899	27	58	53.4	-9.2692	4392
8	11	24	13.0	13	18	46.90	+8.914	28	0	29.3	-9.3821	"
Sept. 1	10	12	11.3	15	34	31.60	+8.729	46	30	14.5	-9.6909	5287
1	10	37	8.7	15	34	32.56	+8.737	46	30	21.4	-9.7283	"
3	8	52	44.6	15	36	47.77	+8.671	46	40	48.6	-9.5688	"
3	9	12	43.0	15	36	48.59	+8.692	46	40	50.8	-9.6042	"

The observations are corrected for refraction. The corrections to be applied for parallax in time and arc are represented by p and q ; P is the equatoreal horizontal parallax. The following are the assumed mean places of the stars of comparison for 1861, Jan. 0.

	R.A.			N.P.D.			Authority.
B.A.C.	h	m	s	°	'	"	
3496	10	7	53.88	24	12	1.54	Greenwich and Oxford Obs.
" 3647	10	32	25.51	23	33	25.95	" " "
" 3968	11	34	41.03	22	29	9.61	British Association Catalogue.
" 4276	12	35	28.67	26	31	24.03	" " "
" 4300	12	41	21.66	26	27	33.40	" " "
" 4392	13	0	53.52	27	12	43.14	" " "
" 5287	15	50	0.14	46	27	17.79	" " "

Variations in the Light of η Argus, observed at Madras from 1853 to 1861. By Eyre B. Powell, Esq.

Mr. Powell writes that he has been engaged, off and on, during the last four years in watching the nebula about η Argus, and in taking micrometrical observations of the neighbouring stars; consequently his attention has been very much directed to that part of the heavens, and the estimations of the magnitude of that star have been made with very great care. The observations are as follows:—

- 1853.991. η Argus slightly inferior to α Centauri, but superior to either α Crucis or β Centauri.
- 1854.076. Inferior to α but superior to β Centauri. Rays issue from η as from Rigel.
- 1855.967. Not brighter than Procyon, and not quite so bright as Capella; scarcely brighter than α Crucis, about equal to β Centauri. Colour reddish or yellowish white; star scintillates.
- 1856.012. Scarcely brighter than β Centauri, a trifle brighter than α Crucis; scintillates more than either, and is reddish. Perhaps equals β Centauri, but, being reddish, strikes the eye more.

- 1858·367. Less than γ *Crucis*, but very little different.
- { 1858·44. Certainly inferior to β *Crucis*, and, I think, to γ *Crucis*.
- { 1858·479. Less than γ *Crucis*.
- { 1858·485. Decidedly less than ν *Crucis*, but is considerably lower. A little brighter than ϵ *Sagittarii*, both stars having about the same altitude.
- { 1859·274. Considerably less than γ *Crucis*.
- { 1859·328. Much less than γ *Crucis*; a little less than δ *Argus*; a little greater than δ *Crucis*.
- { 1859·931. About equal to δ *Centauri*; a little greater than θ *Argus*.
- { 1859·98. Equal to δ *Centauri*; a little greater than θ *Argus*; certainly less than γ *Centauri*.
- { 1860·165. Decidedly less than δ *Centauri*; about equal to δ *Crucis*.
- { 1860·181. Equal to δ *Crucis* nearly, perhaps a trifle superior; both stars require attention to catch them in full moonlight.
- { 1860·287. Equal to δ *Crucis*; not much greater than θ *Argus*.
- { 1860·326. Equal to δ *Crucis*, the stars having about equal altitudes.
- { 1860·972. A little less than δ *Crucis*.
- { 1861·014. Less than δ *Crucis*; less than θ *Argus*.
- { 1861·249. Less than δ *Crucis*; less than θ *Argus*.
- { 1861·282. With telescope, less than the principal star in θ *Argus*.

Taking the observations in groups according to the brackets, and using Sir John Herschel's photometric magnitudes for the reference-stars, the following approximate table is obtained. Where a star of reference does not occur in Sir John Herschel's list (as is the case with δ *Crucis*, for example), '4 has been added to the ordinary magnitude, to bring it to the photometric scale.

Epoch.	Photometric Mag.
1854·03	1·2
1855·99	1·5
1858·44	2·3
1859·3	3·1
1859·95	3·3
1860·24	3·4
1861·13	3·6

The break in the observations between 1856 and 1858 arises from my having been absent from India during that interval.

Madras, November 4th, 1861.

Results of Meridional Observations of Small Planets; Occultation of Stars by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the month of November, 1861.

(Communicated by the Astronomer Royal.)

Victoria (12).

Mean Solar Time of Observation.			R. A. from Observation.	N. P. D. from Observation.
		^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Nov.	2	12 26 22.8	3 15 23.10	69 42 26.18
	7	12 1 26.9	3 10 5.87	70 22 59.01
	8	11 56 27.2	3 9 1.94	70 31 13.92
	11	11 41 30.4	3 5 52.33	70 56 8.14
	19	11 2 1.3	2 57 49.22	72 2 22.22
	20	10 57 9.1	2 56 52.76	72 10 22.27
	30	10 9 31.5	2 48 32.93	73 26 7.39

Irene (14).

Mean Solar Time of Observation.			R. A. from Observation.	N. P. D. from Observation.
		^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Nov.	2	11 36 7.1	2 24 59.11	86 47 6.18
	5	11 21 31.6	2 22 10.86	86 54 23.36
	11	10 52 30.1	2 16 43.98	87 5 52.52
	20	10 9 42.2	2 9 18.07	87 13 59.66
	27	9 37 19.5	2 4 25.97	87 12 8.12
	30	9 23 44.6	2 2 38.52	87 9 1.75

Ariadne (43).

Mean Solar Time of Observation.			R. A. from Observation.	N. P. D. from Observation.
		^h ^m ^s	^h ^m ^s	[°] ['] ["]
1861, Nov.	5	9 30 0.4	0 30 21.41	81 17 5.99
	7	9 21 22.0	0 29 34.71	81 27 33.29
	11	9 4 28.2	0 28 24.37	81 46 22.36
	19	8 32 8.9	0 27 32.20	82 14 58.30
	20	8 28 15.1	0 27 34.28	82 17 27.00
	27	8 1 43.9	0 28 34.64	82 30 34.84

Europa (52).

Mean Solar Time of Observation.			R.A. from Observation.			N.P.D. from Observation.			
	h	m	s	h	m	s	°	'	"
1861, Nov. 5	9	40	50.9	0	41	13.68	95	58	39.84
7	9	32	3.7	0	40	18.14	96	0	29.62
11	9	14	53.1	0	38	50.96	96	3	46.32
20	8	37	17.0	0	36	37.71	95	59	27.43
30	7	57	30.1	0	36	9.84	95	39	58.27

All the observations of N.P.D. have been corrected for refraction and parallax.

Occultations of Stars by the Moon.

Day of Obs.	Phenomenon.	Moon's Limb.	Mean Solar Time.			Observer.
			h	m	s	
1861, Nov. 6	B.A.C. 6448 disapp. (a)	Dark	6	35	26.4	D.
17	33 Tauri, disapp. (b)	Bright	10	12	45.7	J. C.
17	33 Tauri, reapp. (b)	Dark	11	6	51.8	J. C.

(a) Clouds passing over the moon. (b) Somewhat unsatisfactory.
The initials D. and J. C., are those of Mr. Dunkin and Mr. Carpenter.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time.			Observer.
			h	m	s	
1861. Nov. 18	IV	Occ. reapp. first cont. (a)	16	32	4.8	J. C.
18	IV	„ bisection (a)	16	45	34.2	J. C.
18	IV	„ last cont. (a)	16	48	33.7	J. C.
27	I	Ecl. disapp. (b)	14	21	49.4	D.

(a) The planet's image extremely bad. (b) The sky very hazy.
The initials as before.

Observations of Comet II., 1861, made with the Heliometer at the Radcliffe Observatory, Oxford. By the Rev. R. Main.

Day.	Greenwich M.T.			Apparent R.A.			Apparent N.P.D.		
	h	m	s	h	m	s	o	'	"
1861. June 30	11	1	47.4	6	40	13.07	43	25	11.1
	11	29	36.1	6	41	6.02	43	14	34.5
July 2	11	23	2.8	8	32	23.31	27	31	1.1
	11	30	4.3	8	32	45.14	27	29	42.9

Day, 1861.	Greenwich M.T. h m s	Apparent R.A. h m s	Apparent N.P.D. ° ' "
July 3	9 31 58.2	9 38 37.98	24 12 49.7
	9 47 43.2	9 39 24.94	24 11 24.8
4	11 5 17.8	10 51 13.03	23 5 24.7
	11 12 31.1	10 51 31.08	23 5 24.4
5	9 17 25.0	11 42 29.24	23 36 1.9
	9 22 47.1	11 42 39.82	23 36 3.6
	9 26 17.5	11 42 49.05	23 36 21.4
	9 33 42.3	11 43 1.49	
6	9 47 58.0	12 25 1.27	24 53 0.9
	9 52 59.2	12 25 8.45	24 53 24.7
	9 57 8.9	12 25 15.06	24 53 38.7
8	10 27 22.0	13 18 1.07	27 56 35.3
	10 32 14.9	13 18 5.28	27 56 53.7
	10 38 51.7	13 18 10.79	27 57 25.3
	10 43 25.5	13 18 14.18	27 57 37.7
9	9 24 58.9	13 34 7.30	29 18 1.1
	9 33 26.5	13 34 12.91	29 18 39.3
	9 39 15.2	13 34 15.56	29 18 51.2
	10 5 31.0	13 34 30.55	29 20 20.9
10	10 22 28.1	13 47 35.60	30 38 46.1
	10 28 9.6	13 47 38.39	30 39 8.7
	10 33 14.2	13 47 40.79	30 39 25.5
	10 37 7.9	13 47 42.46	30 39 37.2
14	10 43 14.6	14 18 43.61	34 36 9.1
	10 48 39.7	14 18 45.39	34 36 24.7
	10 57 46.4	14 18 46.56	34 36 40.8
	11 6 3.9	14 18 49.10	34 36 58.6
	11 15 44.2	14 18 51.30	34 37 19.9
15	9 44 22.2	14 23 27.83	35 19 24.8
	9 54 15.1	14 23 29.59	35 19 31.6
	10 5 25.7	14 23 31.19	35 19 54.3
16	10 40 16.0	14 27 48.53	36 1 55.8
	10 45 23.2	14 27 49.36	36 2 7.8
	10 51 18.4	14 27 48.82	
	10 57 2.5	14 27 50.92	36 2 20.0
	11 2 53.3	14 27 51.96	
	11 8 22.6	14 27 52.87	
	11 15 53.2		36 2 44.1
	11 21 22.3		36 2 59.5
23	10 43 26.3	14 46 (15.16)	39 27 1.4
	11 16 56.2	14 46 43.04	39 27 19.7
	11 37 21.4	14 46 44.82	39 27 19.1
	12 7 47.9	14 46 46.98	39 27 34.1

July 23. Something wrong in the first observation of R.A.

Day. 1861.	Greenwich M.T. h m s	Apparent R.A. h m s	Apparent N.P.D. ° ' "
July 26	10 13 5'7	14 51 50'00	40 26 14'0
Aug. 1	10 3 43'2	15 0 7'24	42 1 52'4
	10 27 56'9	15 0 7'79	42 1 55'1
	10 44 43'1	15 0 9'40	42 1 55'8
	11 11 31'6	15 0 10'00	42 2 5'3
2	9 40 17'7	15 1 27'09	42 14 43'3
	10 13 40'3	15 1 25'41	42 14 47'8
6	11 3 26'2	15 6 0'50	43 4 3'9
	11 21 32'1	15 6 0'39	43 4 21'1
	11 38 2'0	15 6 1'70	43 4 38'0
	11 53 53'0	15 6 2'55	43 5 2'9
8	11 9 44'2	15 8 14'14	43 26 16'3
	11 31 37'9	15 8 15'83	43 26 13'0
	11 47 20'9	15 8 16'60	43 26 25'4
15	10 55 9'2	15 15 45'79	44 32 44'2
	11 8 42'2	15 15 45'04	43 32 50'0
	11 22 16'8	15 15 47'56	44 32 28'4
16	8 41 9'1	15 16 45'72	44 40 1'4
	8 54 2'8	15 16 46'22	44 40 16'8
	10 6 21'4	15 16 49'40	44 40 29'2
	10 32 28'7	15 16 49'52	44 40 44'6
	10 49 21'9	15 16 50'29	44 40 29'2
19	8 43 2'5	15 19 58'65	45 3 59'6
	9 30 1'7	15 20 0'79	45 4 26'8
	9 43 22'6	15 20 0'96	45 4 29'5
	9 58 29'4	15 20 1'19	45 4 34'8
20	8 35 53'7	15 21 2'46	45 11 45'2
	8 57 18'5	15 21 3'49	45 11 58'8
	9 13 57'0	15 21 3'73	45 11 55'6
	9 48 24'4	15 21 5'75	45 12 6'1
	10 5 56'5	15 21 6'87	45 12 18'4
23	8 48 29'1	15 24 18'35	45 33 24'8
	9 23 49'1	15 24 20'49	45 33 36'9
	9 49 13'5	15 24 20'89	45 33 42'1
	10 1 45'2	15 24 21'31	45 33 44'7
	10 29 47'4	15 24 23'90	45 34 0'0
26	9 28 16'1	15 27 40'96	45 53 47'4
	9 52 15'2	15 27 41'82	45 53 47'7
	10 7 18'8	15 27 42'73	45 54 3'2
	10 16 30'0	15 27 43'56	45 54 10'0
27	8 16 20'7	15 28 43'86	45 59 48'6
	8 41 11'6	15 28 44'71	45 59 53'9
	8 55 45'7	15 28 45'73	45 59 55'9
	9 43 22'5	15 28 48'51	46 0 8'1

Day. 1861.	Greenwich M.T. h m s	Apparent R.A. h m s	Apparent N.P.D. ° ' "
Aug. 27	10 25 55.5	15 28 49.45	46 0 25.7
30	9 15 48.9	15 32 10.80	46 18 22.6
	9 50 49.0	15 32 10.25	46 17 56.3
	10 36 9.5	15 32 15.05	46 17 37.0
Sept. 3	8 15 56.4	15 36 45.81	46 40 20.8
	8 31 56.7	15 36 46.66	46 40 33.7
	9 16 45.7	15 36 49.56	46 40 42.1
	9 36 50.4	15 36 47.67	46 40 44.5
	10 1 3.9	15 36 51.25	46 40 55.3
6	8 32 12.2	15 40 20.60	46 55 41.6
	8 54 41.5	15 40 20.76	46 56 0.9
	9 5 53.6	15 40 22.74	46 55 53.8
	10 2 13.2	15 40 25.27	46 56 11.2
10	8 50 0.4	15 45 13.54	47 14 15.9
	9 10 8.7	15 45 13.66	47 14 28.0
	9 23 45.9	15 45 14.78	47 14 15.2
	9 42 52.8	15 45 15.70	47 14 26.0
12	8 32 28.1	15 47 39.65	47 22 52.6
	9 0 54.2	15 47 42.12	47 22 49.1
	9 20 50.2	15 47 43.15	47 22 49.7
	9 38 57.9	15 47 43.78	47 22 55.3
14	7 53 48.9	15 50 9.91	47 30 31.6
	8 12 44.6	15 50 9.01	47 30 18.5
	8 34 43.2	15 50 12.10	47 30 28.7
	9 13 14.7	15 50 14.21	47 30 42.5
	9 26 59.5	15 50 15.75	47 30 45.9
17	9 14 5.8	15 54 2.74	47 41 37.5

Of the preceding observations, those to July 16 inclusive were made by myself, and the remainder were made by Mr. Quirling. A wire micrometer, furnished with a single fixed transit-wire and with a declination wire moveable by the screw, was used till the faintness of the comet made it necessary to observe in a dark field over thicker wires, when a negative eye-piece with metallic cross was substituted. This change occurred on Aug. 16. But, in all cases, the declination wire was used in a fixed position, and the reading of one microscope of the hour-circle and of one microscope of the declination-circle was taken for each observation of the comet and the stars of comparison. These stars were generally taken from the Radcliffe Catalogue, and were in general so near to the comet on the night of observation that the differential effect of instrumental errors will be insignificant. On July 15 and 16 the transits of the star and comet were made with an unchanged position of the polar axis, though the circles were read as on other evenings, and the results for these evenings are

obtained by application of the index corrections obtained on other evenings.

All the observations are corrected for the effects of refraction and parallax.

The following is a list of the stars of comparison, together with the places assumed in the reduction of the observations.

Mean Places for 1861, Jan. 1, of Stars compared with the Great Comet of 1861.

Day of Comp. 1861.	Name.	Mean R. A. h m s	Mean N.P.D. ° ' "	Authority.
June 30	Capella	5 6 25.55	44 8 53.1	Nautical Almanac.
July 2	ϵ Urs. Maj.	8 18 41.06	28 49 17.5	Radcliffe Catalogue.
3	δ Urs. Maj.	9 20 31.72	26 20 0.7	" "
4	α Urs. Maj.	10 55 7.25	27 29 58.7	Nautical Almanac.
5	" "	" "	" "	" "
"	γ Urs. Maj.	11 46 30.19	35 31 57.0	" "
6	η Urs. Maj.	12 35 28.81	26 31 24.6	Radcliffe Catalogue.
8	δ_3 Urs. Maj.	13 35 27.54	34 36 50.3	" "
9	δ_1 Urs. Maj.	13 28 46.58	33 56 17.7	" "
10	δ_4 Urs. Maj.	13 41 24.15	34 52 19.1	" "
14	*	14 23 49.0	34 38 0.0	
15	*	" "	" "	
16	*	14 27 40.0	36 2 0.0	
"	B.A.C. 4826	14 28 57.27	36 29 21.0	Radcliffe Catalogue.
23	B.A.C. 4937	14 51 46.18	39 48 7.4	" "
26	" "	" "	" "	" "
Aug. 1	44 Boötis (2 ^d)	14 59 12.46	41 48 11.3	" "
2	" "	" "	" "	" "
6	" "	" "	" "	" "
8	Rümker 5030	15 13 32.37	43 52 19.7	Rümker's Cat.
15	Oeltz. Arg. 15347	15 19 24.07	44 14 8.1	Oeltzen-Argel. Cat.
16	Rümker 5050	15 15 53.52	45 3 32.0	Rümker's Cat.
19	Radcliffe 3387	15 21 13.65	45 12 35.4	Radcliffe Catalogue
20	" "	" "	" "	" "
23	Radcliffe 3387	15 21 38.49	45 30 23.4	" "
26	B.A.C. 5175	15 33 40.19	45 56 28.0	" "
27	" "	" "	" "	" "
29	" "	" "	" "	" "
30	" "	" "	" "	" "
Sept. 3	" "	" "	" "	" "
6	Radcliffe 3448	15 41 28.95	47 5 56.0	" "
10	ψ Herculis	15 47 52.16	47 9 27.7	" "
12	" "	" "	" "	" "
14	4 Herculis	15 50 50.05	47 1 39.65	" "
17	" "	" "	" "	" "

On June 30 the comet was also observed on the meridian with the transit-instrument and the meridian-circle, and the following is the result of the observation:—

1861, June 30	12 ^h 11 ^m 58 ^s .9	Greenwich Mean Solar Time.
Apparent R.A.	6 ^h 42 ^m 10 ^s .89	
Apparent N.P.D.	42° 56' 56".1	

the N.P.D. being corrected for refraction and parallax.

The following are the notes which I made on the appearance of the comet:—

1861, June 30. This splendid comet burst suddenly on the view this evening. I saw it first at about 10 o'clock, and immediately prepared to observe it. Its appearance, notwithstanding the strong daylight, was most brilliant. To the naked eye the condensation of light about the head was so great as to bear comparison with the Moon rather than with any other object. In fact the diameter of the coma was about 30' by measurement at some Observatories on this evening. The tail streamed vertically upwards, and near midnight could be traced considerably beyond *Polaris*, which it passed over. Its length on this evening has been variously estimated from 100° to 120° by the most careful observers.

In the telescope of the heliometer there appeared a nucleus of an elliptical shape, with its major axis a little inclined to the vertical, that is, directed nearly towards the Sun. It was about the size of the ball of *Saturn*, near opposition, or about 20" in diameter. A stream of light went off from the upper apparent part of the nucleus, and turned round towards the apparent west in the shape of a sickle. Another but fainter stream was seen on the apparent east side of the first stream, also turning round towards the west.

July 2. In appearance not very different from that on June 30. A sickle-shaped stream of light setting out westward (apparently), and seeming for a little distance parallel to the declination wire, and then turning rapidly downwards (that is, away from the Sun). The nucleus elliptical as before, with its major axis inclined at an angle of 15° to the declination wire. The second stream of light was visible, but not so well defined as before. Clouds rendered physical observations difficult. The tail at least 70° in length.

July 3. The evening was too cloudy for accurate physical observations, but it appeared as if the formations round the nucleus were becoming more regular and concentric, and more like Donati's comet. At midnight the clouds cleared away, and the view of the comet with the naked eye was magnificent. The tail was about 60° in length, being visible beyond the zenith.

July 4. The comet is rapidly becoming fainter. The tail could not be traced farther than 40° from the nucleus, but the brilliancy of the nucleus is still very great. In the telescope the nucleus appeared pear-shaped, with the point (apparently westward) and the axis parallel to the declination axis. Two curved streams of light are still seen flowing from it, the lower one sickle-shaped, but not so well defined as previously, cutting the declination wire at an angle of about 60° ; the upper are ill defined and cutting the declination wire at an angle of 30° . The whole formed the sector of a circle of about 100° .

July 5. I examined the head of the comet to-night with a lower power. The nucleus is now very bright, and almost equal to a star of the first magnitude (I compared with α *Ursæ Majoris* in the twilight). It is of the same shape as on the preceding night. The head of the comet is altogether like a fan expanded to about 120° . Round the nucleus is a very bright circle of light, scarcely separable from it, and the two diverging streams of light now pass symmetrically on each side of the nucleus.

July 9. The shape of the head is that of an expanded fan. The nucleus terminates in a bright stellar point towards the apparent east, and is very narrow and pear-shaped, running parallel to the declination wire (or to the equator). Round the nucleus is a bright envelope of a circular shape, and, beyond that, another very faint and diffused. The distinctness of the envelope is not at all comparable with Donati's comet of 1858. The whole of the field is very strongly illuminated with the light of the comet.

July 10. The appearance of the comet has not materially changed since last night, except that the shape of the nucleus is materially different, having become more obtuse.

By my directions, Mr. Quirling confined himself for several evenings after the first appearance of the comet to observations of the length, breadth, and peculiarities of the tail, and incorporated the results of his observations in a series of drawings, in which the position and magnitude of the tail are defined accurately by means of the stars which it passed over or near to. The following is an abstract of his observations:—

“July 4. This was the first favourable evening after June 30 for observations of the tail. At $10^h 40^m$ the head of the comet was nearly in a line with α and β *Ursæ Majoris*, and the northern boundary of the tail passed just over α *Draconis*, and could be traced a short distance beyond that star. The estimated length was about 25° . The shape near the head was that of a very flat parabola, and the northern boundary was by far the brighter one.

“At $11^h 30^m$, the darkness being greater, the comet had increased considerably in apparent brightness. The northern border of the tail passed beyond α and γ *Draconis*, which were seen through it; it passed exactly over γ *Draconis*, and could

be traced towards τ *Herculis*. The southern border was far less distinct; it passed north of δ *Draconis*, of several stars of the 6th magnitude. Estimated length, about 44° .

"At 12^h , the northern border could be traced beyond η *Herculis*; the southern border still less distinct than the northern. In the vicinity of δ *Draconis* there seemed to be faint traces of a second tail. Whole length of tail, 60° to 65° ; breadth, 7° to 8° .

"July 5, $11^h 30^m$. Sky very fine. The tail could be traced nearly to τ *Herculis*, the northern boundary being still the better defined. The southern border scarcely reached δ *Draconis*, and passed over ι and κ *Böotis*, where there was again the faint beginning of a second tail, bending northwards, as on the night before. The tail did not reach τ *Herculis*. Length, about 45° ; greatest breadth, 10° .

"July 8, $11^h 30^m$. The evening in general not favourable. The comet considerably fainter than on July 5, but still a conspicuous object in the heavens. The centre of the tail pointed midway between ϵ and χ *Herculis*; but it could not be traced up to those stars. The fan or second tail, which was observed on July 4 and 5, had entirely disappeared. Length, about 27° .

"July 9. General appearance nearly the same as on the preceding night. Length, about 20° to 24° .

"July 14. The comet considerably smaller. The head, which had been up to this time always estimated as of the 1st and 2d magnitude, was to-night decidedly not brighter than a star of the 3d magnitude. Both borders of the tail well defined, though the northern could be traced farther than the southern. Length of tail, 15° or 16° .

"July 16. The appearance very similar to that on July 14. Length, 12° or 13° ."

Progress of the Charts in course of execution at Bonn.

Communicated by Mr. Carrington, as received from Dr. Krüger, by the direction of Dr. Argelander.

Seven sections, each comprising four sheets, are published. The first four sections were received several months since by the Observatories and Astronomers to whom they are presented. Sections 5, 6, and 7 were despatched, through Marcus of Bonn, at the end of last October; and vols. iii. and iv. of the *Bonn Observations*, being vols. i. and ii. of the present *Survey*, are about to follow. The charts comprising the Zone 2° S. to 20° N., and the next, 20° N. to 40° N., are fully published; and section 7, containing sheets 26, 27, 32, 33, will amount to half the next Zone, 40° to 60° N.

The observations by zones of 2 and 3 degrees broad with the 34-lines telescope were brought to a close at 81° N. on March 27, 1859, and amount to 1841 zones. By means of auxiliary tables, the positions of all the stars of Bessel's zones, from $+15^{\circ}$ to $+45^{\circ}$ from Weisse's catalogue, Oeltzen's catalogue, &c. were brought up to 1855.0, and entered in the same ledgers (about 190 in number), which record the original entries of times of transit in the Bonn zones. In order to see by inspection that each star was twice observed, a special catalogue was transcribed, in which the positions were arranged in zones of one hour each, and one degree broad. When the two observations of each star had been thus compared, the next step was the reduction to 1855 of all the stars contained in the former Catalogues of Lalande, Bessel, Argelander, Piazzzi, Groombridge, Johnson, Rümker, Fedorenko, Schwed, Struve (*Pos. Med.*), &c.; and the entering of the results alongside of those of the *Bonn Survey*; when, if the different authorities exhibited marked discrepancies, a further research was instituted. All cases of discrepancy were put aside, and entered in books for further examination or reobservation where the source of error was not easily detected.

The re-examination of the still dubious cases has been, for the most part, the special labour of Dr. Argelander himself, and a very laborious and important part of the undertaking, the necessary observations on the meridian having engaged his whole time from 1854 to 1860.

It has further been found necessary to repeat the survey in portions of the heavens unusually rich in stars, or where the previous ordinary survey had been taken during moonshine. For this purpose 476 additional Revision-Zones have been observed with a 5-foot telescope, by taking 1° only at a time in breadth, and on an average a much less extent in right ascension than those of the first survey.

In addition to the revision of doubtful stars, Professor Argelander has completely observed all stars to the 8th magnitude the positions whereof were found to be previously undetermined. The results of these observations will be embodied in a separate catalogue of about 30,000 stars observed with the meridian circle. The revision-observations of this class have been long in progress, so that the number of still undetermined stars is reduced to about 1000, and the whole is likely to be finished next summer. The reduction of these observations is somewhat in arrear, and a year or more may be required before the catalogue can be formed.

Dr. Krüger proceeds to remark, that after the correction of all known errors, the next step was the preparation of the principal catalogue, the arrangement of which he describes, but which can be seen by inspection of the work itself. He points out that the fourth volume contains a catalogue of all the errors detected at Bonn in the zones of Bessel, from -2°

to $+45^{\circ}$ decl., and states that the result of the revision appears to be, that, excepting two cases of observations of planets, the whole of the observations of Bessel agree with positions of stars which still exist. He remarks that the result affords a weighty argument against those who hastily speak of vanished stars, and that the stability of the heavens has received so strong a support that suppositions of sudden change will in future be received with the greatest mistrust.

The preparation of the principal catalogue was assigned to Prof. Schonfeld, who has continued to forward the work since his removal to Mannheim; so that now the manuscript is complete.

The preceding account relates to north declination to 81° . It was considered impossible to continue the observations in zones beyond this point, on account of the extremely slow movement of the stars, and recourse was had to the first issue of Mr. Carrington's Charts (those printed by the anastatic process), which were compared anew with the heavens by means of a large comet-seeker, the magnitudes noted, and wanting stars supplied—the last by use of the heliometer.

To complete this work there now remains only the plotting out of certain charts, and the printing by lithography; and only three sheets besides the polar chart are incomplete. The rest are partly finished, partly in the press, and partly in MSS.

The catalogue progresses simultaneously, and the third section is in the press. When this is done, there will follow the special catalogue of 30,000 stars observed on the meridian, and the correction of errors in the *Histoire Celeste*, Argelander's Northern Zones, and other catalogues.

The Fellows of the Society, and all to whom this account comes, cannot fail to admire the stately progress of this enormous work, which, simple in its conception, and free from insurmountable difficulties in execution, would appal many an astronomer by its vast extent.

The President communicated a letter from Mr. Basil Henry Cooper, "On the Egyptian Phoenix Period of 540 years, spoken of in a passage of Pliny." The letter partly relates to an eclipse of the Moon, recorded in a hieroglyphical inscription at Karnak, which the author concludes to have been that of the night of the 16 March, B.C. 851.

The President communicated observations by Mr. S. Horton of Encke's Comet, and of the planet *Saturn*, extracted from the Hartwell Observatory Register. The comet was seen:—

	1861, Nov. 24.	Nov. 26.	Nov. 30.
Right Ascension	22 ^h 31 ^m	22 ^h 29 ^m	22 ^h 25 ^m
Declination	7° 53'	7° 29'	6° 49'
Hour Angle	2 ^h 13 ^m	4 ^h	2 ^h
Clock	0 ^h 45 ^m	2 ^h 31 ^m	0 ^h 26 ^m

Power 22 and 50.

Among the presents to the Society was included a volume of 111 Indian-ink drawings, by Mr. S. Gorton, of the planet *Jupiter*, radius about one inch, from observations made at Downs Road, Clapton, in the years 1859–60–61. The author remarks that as the observations were taken for the purpose of recording any great or marked changes in the principal belts, with an instrument of moderate size, the representation of those minute details for which great power was necessary was not attempted. The earlier drawings were made under some disadvantages—the telescope being used at a window, and not having an equatoreal mounting; this was added in April 1860, after which the planet was observed more regularly.

The power used was almost invariably 100; the telescope by Ross, 4 feet focal length, $3\frac{1}{8}$ inches aperture.

An Account of Observations on Solar Radiation.

By John James Waterston, Esq.

§ 1. In March of last year I submitted to the Society some computations with reference to the Sun's heat, and suggesting a mode of deducing the potential temperature of its radiating surface. This last summer I have endeavoured to put this method to the proof by a series of observations on solar radiation, supplemented with experiments on the rate of cooling of thermometers in air and in vacuo with different kinds of radiating surfaces; also by another series applying the method of deducing the potential temperature of a radiating surface to predicate the temperature of one that is maintained at a constant *known* temperature.

The success of these last mentioned, so far as they have as yet been carried, encourages me to lay before the Society the observations on solar radiation, with an account of the method

employed to obtain the results, and of the mode of reducing them to a vacuum.

§ 2. It will be remarked, on inspecting the chart in which the observations are projected, that a simple law of atmospheric absorption is indicated, which, if confirmed by other similar observations in different climates, would perhaps lead to more exact ideas of the influence of the atmosphere on the Sun's rays. Unfortunately the best part of the summer had passed before I could begin to observe, and there was almost constant interruption with clouds and unsettled weather. In a tropical station, where the Sun rules in a cloudless sky, the presumed law might soon be put to the test, and the heating power of the Sun's rays before entering the atmosphere ascertained with precision. Having determined this for the Earth's mean distance from the Sun, its value for any other planetary distance may be deduced by the law of the inverse square.

§ 3. When a thermometer is exposed to the Sun with its bulb blackened, it is presumed to absorb all the heat that impinges on a plane surface equal to the transverse section of the bulb; it rises and is maintained at a certain temperature; and when this balanced condition is attained we can with certainty assert that the amount that issues from the bulb is precisely equal to the quantity that enters. The elevation of its temperature above surrounding bodies due to the Sun's radiant power (which is denoted by the symbol r) would be an exact measure of that power, if no heat issued from it except by radiation, and if the rate at which heat was emitted from it increased exactly in proportion to r . Now I find that if the bulb of a thermometer is enclosed in a vacuum, the walls of which are brass, coated with lamp-black, the rate at which it cools is *exactly* proportional to the value of r , and this rate has exactly the same value, whether the glass bulb is uncoated or coated with lamp-black. When enclosed in air the rate of cooling increases faster than r . The mode of measuring the rate in both cases, and of reducing the values of r observed in air to what they would be in a vacuum, are described at the end of this paper.

§ 4. The instrument employed was designed so that the thermometer exposed to the Sun's rays should radiate against an enclosing metallic surface coated with lamp-black, and so that the temperature of that surface should always be known.

Fig. 1, with the description that accompanies it, gives the details. The rays of the Sun were admitted to strike upon the bulb of the thermometer, x , through a hole but little larger than its diameter, and were entirely screened off the brass tube against the blackened inner surface of which the radiation of the bulb took place. The thickness of the sides of the brass tube was $\frac{1}{4}$ inch, and the thermometer, x , that indicated its temperature, was lodged in a hole cut in the upper side. The circumference of the bulb touched the brass, and its upper side

was enclosed with cork, while the lower was exposed to the air within the tube, but was untouched by the rays of the Sun that passed through. The internal diameter of the tube was 0.9 inch and length 6 inches. The bulb of the solar thermometer was 0.42 inch in diameter, spherical in shape, and fixed in the centre, as shown in the figure. Its shadow was an easy guide in moving the tube in altitude and azimuth to keep pace with the Sun. It is difficult, if not impossible, to demonstrate that the thermometer, *x*, shows the exact temperature of the inner surface of the tube. It was subjected to three tests.

1. The instrument being out of the Sun's rays, and *x* and *y* showing the same temperature, it was removed to a place where the atmospheric temperature was 10° lower. Both thermometers descended and showed a difference equal to about one-tenth the amount they had to fall to arrive at the atmospheric temperature, *y* being so much in advance of *x*.

2. A bat's-wing flame of gas was brought within 3 inches fronting the middle of the tube; both *x* and *y* rose together, keeping pace exactly.

3. While taking observations, the heat absorbed by *x* from the Sun, and again emitted from it and transferred to the tube, gradually raised its temperature until a maximum was obtained. Now, comparing *x* and *y* while both are rising, and after having obtained their maximum, a difference of 0.3 was remarked, and this difference, no doubt, affected isolated observations when this maximum was not attained, in consequence of interruption by clouds passing, when it was usual to heat the solar thermometer artificially to near the stationary point, in order to save time; the great inconvenience of the apparatus in this climate being the slowness with which *x* obtained its final value. An arrangement with a differential air-thermometer would, no doubt, be preferable in this respect, but the absolute value of the degrees indicated does not seem capable of being exactly determined.

The thermometers were carefully graduated and compared by myself, and the divisions between two fixed points, 60° and 100° (which included all the observed temperatures), were drawn as nearly equal as a good ivory scale and magnifying lens would admit. The length of a degree on the scale of *y* was about .05 inch, and upon *x* .067 inch; with practised eye it was easy to read off the temperature to $\frac{1}{20}$ th of a degree with lens; but such accuracy was unattainable for other reasons, and chiefly a sensible difference was caused by the varying amount of the stem that was under the influence of the Sun's rays as it moved.

The observations taken on the morning of the 21st August continuously, during $2\frac{1}{2}$ hours of uninterrupted sunshine, were graphically equalised, the curve drawn and ordinates measured off at every 20 minutes. This was the only opportunity that occurred of continuous observation between such favourable

limits of altitude as to indicate the direction of a line with some precision.

In the table of observations, given in the Appendix, the date and apparent time are given in the first column. The time-piece was regulated daily by the one o'clock signal-gun. The second column contains the values of r , the observed difference between thermometers x and y . The film of talc that was interposed between the Sun and x was found to reflect $\frac{9}{50}$ th of the incident rays. This ratio was determined by observations taken with the film off during calm weather. The value of r without the film to r with the film on, was as 1.18 to 1.00; the sun's power not sensibly varying during the interval. This proportion was maintained at low values of r , and even when the source of radiation was a gas-flame. The third column contains the observed values of r increased in this ratio. The fourth column contains the corrections required to reduce the values in the third to a vacuum. The correction is taken from a scale that was constructed by means of an empirical formula derived from observations on the cooling of x , as detailed in the Appendix. The fifth column is the final value of r as it would appear in a naked vacuum, that is, a vacuum without any interposed transparent solid between the Sun and the bulb of the thermometer. The numbers in this column represent the quantity of heat-force supplied from the Sun to the bulb of the thermometer in a constant element of time, or the quantity that emanates from the bulb in a unit of time.

The experiments on the cooling of the thermometer, x , in a vacuum, show that from $r = 30^\circ$ to $r = 15^\circ$, the time of cooling was 294 beats of a time-piece, of which $77\frac{1}{2}$ were equal to 60 seconds; also from $r = 15^\circ$ to $r = 7\frac{1}{2}^\circ$, the time was the same, and generally from $r = 2m$ to $r = m$ the elapsed time is the constant 294, which thus represents the logarithm of z in the logarithmic curve, of which the ordinates are r and the abscissæ the time of cooling, t . The equation of the curve being $c \log \frac{r_1}{r_0} = t_1 - t_0$, in which $c \log z = 294$, or to reduce to seconds, $c \log z = 294 \times \frac{60}{77\frac{1}{2}}$, and $c = 756.1$. Let $t_1 - t_0 = \delta t$, then $\log \frac{r_1}{r_0} = \frac{1}{\mu} \cdot \frac{\delta r}{r}$, in which $\mu = \text{hyp. log of } 10$; hence

$$\frac{c}{\mu} \cdot \frac{\delta r}{r} = \delta t \quad \left[\log \frac{c}{\mu} = 2.51636 \right].$$

From this we may compute the quantity of heat supplied to a unit of surface by the Sun in a unit of time corresponding to any value of r . As an example, suppose $r = 10^\circ$ and $\delta t = 1$ second, then $\delta r = \frac{10\mu}{c} = 0.030453$, or 3.0453 in 100 seconds, is the rate at which the Sun communicates heat to a thermometer, whose bulb is a sphere 0.42 inch in diameter, when $r = 10^\circ$.

Suppose the glass of the bulb to be $\frac{1}{50}$ th of an inch thick, there would be $\cdot 0108$ cubic inch glass and $\cdot 0287$ cubic inch mercury heated $3^{\circ} \cdot 045$ in 100 seconds. If $r = 20^{\circ}$, the same heating would take place in 50 seconds, and so on.

To reduce this to thickness of ice melted in 1 minute, we have

Specific heat of mercury $\cdot 033$ and of glass $\cdot 177$.

Specific gravity of mercury $13\cdot 5$ and of glass $2\cdot 9$.

$\cdot 0108$ cubic inch glass equal in weight to $\cdot 0313$ cubic inch water.

$\cdot 0287$ cubic inch mercury equal in weight to $\cdot 387$ cubic inch water.

$\cdot 0108$ cubic inch glass raised $3^{\circ} \cdot 045$ takes as much heat as $\cdot 0313$ cubic inch water raised $0^{\circ} \cdot 54$.

$\cdot 0287$ cubic inch mercury raised $3^{\circ} \cdot 045$ takes as much heat as $\cdot 387$ cubic inch water raised $0^{\circ} \cdot 101$.

$\cdot 0313$ cubic inch water raised $0^{\circ} \cdot 54$ takes as much heat as is required to raise 1 cubic inch $0^{\circ} \cdot 0169$.

$\cdot 387$ cubic inch water raised $0^{\circ} \cdot 101$ takes as much heat as is required to raise 1 cubic inch $0^{\circ} \cdot 0391$.

The entire bulb of the thermometer thus raised $3^{\circ} \cdot 045$ is thus equal to 1 cub. in. of water raised $\cdot 0169 + \cdot 0391 = 0^{\circ} \cdot 056$.

Now, the transverse section of bulb is $0\cdot 138$ square inch; and since specific gravity of ice is $0\cdot 93$, and it requires 140° to melt ice, we have $140 \times 0\cdot 738 \times 0\cdot 93 \times x = 3\cdot 045$; hence $x = 0\cdot 00312$ inch, the thickness of ice melted by the Sun in 100 seconds, when $r = 10^{\circ}$. This is equivalent to $0\cdot 001872$ inch in 1 minute. With $r = 20^{\circ}$ the thickness would be double this amount, and so on. Thus the presumed extra atmospheric value of r being 67° gives $0\cdot 0124$ inch thickness melted per minute.

From June to December the amount may be expected to vary $\frac{1}{15}$ th, corresponding to alteration of Sun's distance. In Herschel's *Meteorology* the probable thickness is stated to be $\cdot 0109$ inch.

If the law indicated by straight lines on the chart is true it would require extremely accurate observations to give the extra atmospheric constant of solar radiation with precision. From a single observation made in Bombay some years ago I am disposed to believe it may exceed 67° considerably.

The mode of approaching the law of absorption is as follows:—Project the values of r as ordinates to the secants of zenith distances as abscissæ. The resulting curve is evidently hyperbolic in character. If it is the conic hyperbola, the reciprocals of the ordinates laid off to the same abscissæ should range in a straight line. The obvious plan is, therefore, to lay off the reciprocals of r in this way, and see how far their range agrees with the straight, and, if it differs, the character of the

divergence might lead us to the true function that expresses the natural law, if it was not very complicated, and if the condition of the atmosphere did not vary so rapidly as to obscure it.

The observations, though taken under unfavourable conditions, favour the simple hyperbola.

It will be remarked, on inspecting the chart, that the value of r at the same altitude of the Sun diminishes with the declination as the season advances. If continuous observations were possible for a few hours each day, when the altitude of the sun ranged between 15° and 45° , we might expect to see the projection of the equalised observations range each day in a different line; but these lines ought all to converge on nearly the same point in the ordinate at the zero of the secant scale, if the law holds good. The lines A C, A D, A E, will exemplify this.

Let N, fig. 3, be the position of the observer, z his zenith, and NS the direction of the sun. Draw parallel lines ab , cd , &c.; now $ac : bd :: \text{rad.} : \text{sec. sun's zenith distance}$, so that the thickness of each stratum varies as the secant; and if the physical condition of the stratum did not alter between two observations, we may take the secant as the representative of the collective thickness of the absorbing medium traversed by the Sun's rays, except at such low altitudes when the curvature of the earth as well as refraction may be expected to introduce uncertainty. The minimum value of the secant is radius, but we may imagine the Sun's rays to pass through a similarly constituted atmosphere in which the thickness of the same layers proportionally diminishes from unity or radius to zero. The reciprocal of r diminished for values below radius at the same rate as for values above radius, attains at zero the extra atmospheric limit which, in all climates and seasons, ought to be determined by the inverse square of our planet's distance from the Sun in its orbit, and should not vary beyond $\frac{1}{30}$ th of its mean value.

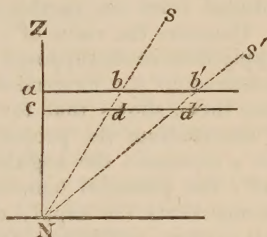


Fig. 3.

Let m_0 , m_1 , be the secants at which the radiation is r_0 , r_1 , we have, according to the projection $\frac{m_0 - m_1}{\frac{1}{r_0} - \frac{1}{r_1}} = k$, a constant

quantity, so long as the physical condition of the atmosphere remains constant; and to find R, the extra atmospheric value of r , we have

$$m_0 - m_1 : \frac{1}{r_0} - \frac{1}{r_1} :: m_1 : \frac{1}{r_1} - \frac{1}{R}.$$

Hence $m = \frac{k}{r} - \frac{k}{R}$ and $\frac{1}{R} = \frac{1}{r} - \frac{m}{k}$. Since R is constant, we may put $\frac{k}{R} = e$, so that $r = \frac{k}{m+e}$. This expresses the presumed law of absorption or interception.

The essential nature of this law is seen by studying the proportionate differential of r ,

$$-\delta r = \frac{k \delta m}{(m+e)^2} \text{ and } \frac{-\delta r}{r} = \frac{\delta m}{m+e} = \delta m \frac{r}{k}; \text{ hence } \frac{-\delta r}{\delta m} \propto r^2.$$

Thus the Sun's rays, in passing through a constant element of the thickness of the atmospheric medium, loses a proportionate amount of its power that is not constant, but that diminishes in the simple ratio of that power.

As an example, suppose with $r = 30^\circ$, the value diminishes 1° in passing through 1 mile, it would only lose $\frac{1}{4}^\circ$ in passing through the same mile if $r = 15^\circ$, and $\frac{1}{900}$ th of a degree if $r = 1^\circ$. We might thus expect, when the atmosphere is clear, it does not intercept any sensible proportion of the heat radiated from the earth's surface into space.

Compare the value of r with one Sun and with two; the supply from each, supposed equal, doubles the value of r , which, measured at the extremities of the mile nearest and furthest from them, shows that for the same element of the thickness of the medium the proportionate decrement of r is constant. Let α represent the angular space occupied by the Sun's disk, and t the potential temperature of its radiating surface, then $t\alpha$ represents the supply of heat by radiation from it upon a unit surface, and is measured by r , so that if αt becomes $2\alpha t$, r becomes $2r$. Now, the factor 2 may have reference to α , the magnitude of the Sun's disk, or it may have reference to t , its temperature. The fluctuating value of r from change of altitude or climate represents a fluctuating potential value of αt , but α being constant, the change is similar to what would take place above the atmosphere by a change in t alone. At different parts of the earth's orbit the value of α changes, so that with t constant and α variable the proportionate absorption represented by $\frac{\delta r}{r \delta m}$ is a constant quantity, but so far as r depends on t the value $\frac{\delta r}{r \delta m}$ increases with t , and the causal relation may be expressed as follows:—

The heat-pulse travels, carrying with it an intensity that it borrows from the temperature of its source, and encounters a deflecting or absorbing power in passing through a constant element of the atmospheric medium that is exactly proportional to that intensity.

It would be simpler if the resistance was uniform,—if the proportion of force absorbed was constant; but the observations do not admit of the possibility of this. The curve traced out

by the co-ordinates, r and secant zenith distance, would in that case be no longer the conic hyperbola, but the logarithmic curve.

At 6 o'clock in the evening of the 31st July, while making an observation, an extensive shower of thin rain took place overhead and westward towards the Sun, without sensibly obscuring its light or affecting its image when examined through a telescope. The value of r descended immediately from 15° to 13° . The single observation I took in India, compared with those taken at the same altitude in this country, indicates that the value of r is there fully double what it is here, while the quantity of vapour held in suspension estimated from the dew-point is certainly greater. It would seem probable, therefore, that the absorbing power of the atmosphere depends on the watery particles contained in it, not upon the aqueous vapour dissolved in it.

[The Appendix, received simultaneously with the foregoing, will appear in the following number of the *Notices*.—ED.]

26 Royal Crescent, Edinburgh, Nov. 25, 1861.

Explanation of the figures.

Fig. 1. T, U, B, E, is a square tube of brass, mounted with motion in altitude upon an upright, R, fixed into a round slab of lead. The inner surface of this tube is blackened, and at each end, at l and c , a film of transparent talc was stuck on to prevent the wind from moving the air within the tube.

H, D, D, H, a double screen made of cardboard and cork, coated on both sides with tin-foil, and fitted to slip on the extremity of the tube presented towards the sun.

m , the hole in centre of screen, about $\frac{1}{10}$ th inch greater diameter than the bulb of the solar thermometer, x.

The talc film, l , was also coated with tin-foil except the central circle.

x, the thermometer in sun with spherical bulb fixed in a cork that fitted the hole, L, L, in top of brass tube.

y, the thermometer in the shade fixed in the hole, N, N, with cork and soft wax as shown.

z, a thermometer applied to outer surface of tube.

Fig. 2 is a transverse section of vacuum bath, employed to ascertain the rate of cooling of the solar thermometer, x, in air and in vacuo.

It consists of a cylindrical vessel of brass, coated internally with lamp-black; the lid, L, is ground to the upper edge of the cylinder, and in its centre is a stuffing box, s, with Indian-rubber collar, through which the stem of the thermometer is passed, as shown in the figure; c, is a stop-cock, upon which, N, the nozzle of a flexible tube communicating with an air-pump, is ground air-tight. H is a wooden handle for removing the apparatus to and from the bath without touching the metal.

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